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The Implications of Packaging Plastic Recycling on Climate Change Mitigation and Fossil Resource Savings – A Case Study in Japan

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ABSTRACT

Waste recycling activities contribute to critical environmental challenges such as Greenhouse gas (GHG) emissions and depletion of fossil resources, mainly due to the consumption of fossil energy. However, material recovery from waste recycling can offset both GHG emissions and resource depletion that would otherwise occur through the production of an equivalent amount of materials through virgin production processes. This study aims to assess the effects of packaging plastics recycling on GHG mitigation and resource saving by using a practical example in Yokohama. In order to quantify the environmental impacts, the life cycle assessment framework was designed by taking into consideration all of the phases of the life-cycle such as transportation, baling, recycling etc. The functional unit was defined as one tonne of packaging plastic waste recycled in a recycling plant in Shizuoka.

The potential material recovery from recycling amounted to 903 kg of plastic granules per tonne of plastic waste and thereby it is assumed that an equivalent amount of virgin plastic production could be eliminated. Credits were provided for avoided GHG emissions and resource consumption via the virgin resin production process. The estimated net GHG emissions and net fossil resource consumption amounted to -853 kg CO_2-eq and -1,374 kg crude oil-eq per tonne of recycled packaging plastic respectively. The resulting negative values indicate that packaging plastic recycling can make a significant contribution to GHG emissions mitigation and can significantly contribute to avoiding the depletion of fossil resources.

Keywords: Recycling, packaging plastic, LCA, Japan

INTRODUCTION

The lack of adequate land for landfilling is a major problem in Japan. The country is pursuing a sound material recycle oriented society both to achieve sustainable development and to reduce the amount of waste that is incinerated and disposed of in landfills. Yokohama, the largest Japanese city by population (3.67 million people), produced 1,280,000 tonnes of waste in 2009. Yokohama city is aiming to reduce the amount of waste generated to 1,240,000 tonnes in year 2013 under the 3R dream plan (City of Yokohama Resources and Waste Recycling Bureau, 2011). The waste was treated using a combination of technologies, including recycling (27.3%), incineration (71.9%) and landfilling (0.8%).

On average, 134 tonnes/day of source separated packaging plastic waste is collected and transported by private companies using compactor trucks followed by baling. The baled plastic is then transported to several facilities, which are situated in different prefectures, for recycling. Approximately 14%-15% of the collected packaging plastic in Yokohama is transported to the recycling facility which is situated in Shizuoka prefecture. This study focuses key environmental implications of packaging plastic recycling process using the practical case in Shizuoka. GHG emissions and their influence on climate change and the depletion of fossil fuels are considered to be critical global environmental challenges. Recycling activities contribute to the global environmental challenges of GHG emissions and the depletion of fossil resources (Menikpura et al., 2011). However, material recovery from plastic recycling can offset the GHG emissions and resource depletion that would otherwise occur through the production of virgin resin. Therefore, in this study, the effects of packaging plastics recycling on GHG mitigations and resource saving were assessed using the case of packaging plastics recycling in Shizuoka.

METHODOLOGY

Framework for the assessment

In order to quantify the environmental impacts, the Life Cycle Assessment (LCA) framework was designed considering all the phases of the life-cycle, namely; collection of source separated plastic, transportation to the baling facility, baling, long distance transportation, and production of plastic granules through the recycling process. In addition, system expansion was used to account for the effects of material recovery. Thus, credits were provided to account for the avoided virgin production of materials which had been recovered as a result of recycling. The functional unit was defined as 1 tonne of packaging plastic waste recycled in a recycling plant in Shizuoka. The recycled plastic in the Shizuoka plant falls into three major categories viz: polyethylene (PE), polypropylene (PP) and polystyrene (PS) at 56%, 38% and 6% respectively. Plastic pellets are the final product from the PE and PP recycling processes whereas plastics ingots are produced from recycling PS.

Inventory data was collected with respect to all the activities involved in the recycling process of packaging plastics. Mainly plant specific information was gathered on energy and material consumption for the overall plastic recycling process at the Shizuoka plant. Additionally, literature data sources were used to find information related to waste collection, transportation, baling etc. Furthermore, the plastic manufacturing process from virgin materials was studied in the Japanese context in order to estimate the potential credited impacts from the recovered materials**.** Inventory data for virgin production of plastic granules was obtained from the Plastic Waste Management Institute (2009), Japan.

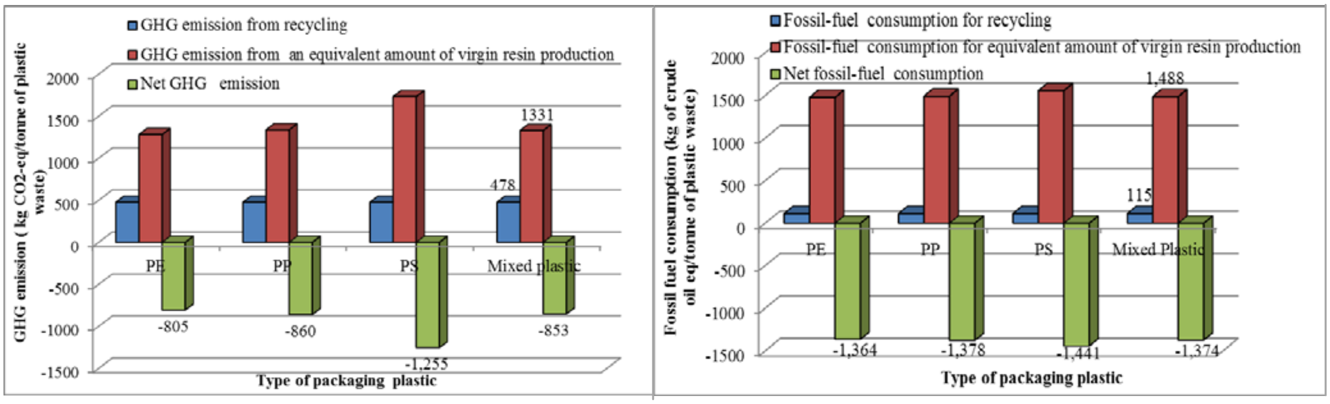
Indicators for the quantification of the impacts

Appropriate indicators were identified in order to assess the environmental implications of packaging plastic recycling activities. It was found that all kinds of recycling activities are associated with a significant amount of fossil energy consumption in the form of diesel fuel, grid electricity and thermal energy. This contributes to greenhouse gas (GHG) emissions as well as fossil resource depletion. In contrast, the materials recovered as a result of recycling enable to gain environmental benefits from the avoided virgin production of such materials and related GHG emissions. In order to quantify the overall environmental implications of recycling activities, net GHG emissions potential and net fossil fuel consumption potential were therefore identified as the most relevant environmental indicators. In order to estimate the climate impact, all the GHGs were considered, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The GHG mitigation potential is expressed in the unit of CO_2 equivalent. Fossil fuel consumption potential is expressed in crude oil equivalents (42 MJ/kg, in ground).

RESULTS AND DISCUSSION

In order to calculate the overall GHG emissions and fossil fuel consumption from the packaging plastic recycling, overall fossil fuel and grid electricity consumption were accounted for, considering all the phases of their life cycle. For instance, the diesel fuel requirement for plastic waste collection and transportation by compactor trucks (2.06L/tonne of plastic waste), grid electricity consumption for baling of plastic waste (29.85 kWh/tonne of plastic waste), diesel fuel requirement for long distance transportation (distance from Yokohama to Shizuoka is 426 km) of baled plastics (11.11 L/tonne of plastic waste), and grid electricity consumption for the recycling process at Shizuoka (1,005.86 kWh/tonne of plastic waste) were taken into account for this assessment. Then, GHG emissions and fossil resource consumption were accounted for with respect to all the recycling processes. Furthermore, in order to realise the effectiveness of the recycling of packaging plastics, the project emissions were compared with the virgin production of the same amount of plastic resin in Japan. According to the plant specific information at Shizuoka, 9.7% of weight loss may occur during the cleaning and recycling process. Therefore, there is the possibility of recovering 903 kg of plastic granules per tonne of waste plastic. In order to compare the real effects of recycling on GHG mitigation and resource saving, production of 903 kg of virgin plastic resin was studied by using the inventory data that has been published by the Plastic Waste Management Institute (2009), Japan.

From the inventory data collected, GHG emissions and fossil fuel consumption were calculated as shown in Figure 1 (a) and (b). According to the analysis, virgin resin production contributes to higher GHG emissions and fossil fuel consumption than the recycling process, mainly due to the large amount of fossil energy required for virgin production and related emissions. The estimated GHG emissions and fossil resource consumption amounted to -853 kg CO_2-eq and -1,374 kg crude oil-eq per tonne of recycled waste packaging plastic. The resulting negative values indicate that packaging plastic recycling can make a significant contribution to mitigating GHG emissions and avoiding the depletion of fossil resources. The results of this study highlight the environmental benefits of packaging plastic recycling. The authors hope that these findings can strengthen the rationale for plastics recycling and thereby contribute to convincing stakeholders involved in waste management about the need for strengthened support for such recycling to replace incineration and landfilling of this waste.



(a) (b)

Figure 1: (a) GHG emissions (b) fossil-fuel consumption from packaging plastic recycling and virgin production

CONCLUSION

The results of packaging plastic recycling process in Yokohama clearly show that packaging plastic recycling in an appropriate way for material recovery offers important prospects since it provides significant environmental benefits and therefore contribute to improve sustainability of the waste management system in place. The results of this study could be used as a probing tool to convince all stakeholders involved in waste management of the benefits of packing plastics recycling and, as well as promoting and strengthening such recycling activities in Japan and elsewhere.

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